

A study of some anatomical characters of North American Gramineæ. III.

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Distichlis and Pleuropogon.

(WITH PLATES XXIII AND XXIV.)

Distichlis maritima Rafinesque. — While engaged in studying the leaf-structure of *Uniola Palmeri* Vasey, I was well aware of the great similarity that exists between this species and the genus *Distichlis* in external characters of the inflorescence, the rhizome, and the rigid, densely 2-ranked, involute leaves. Now having examined the anatomy of the leaf of a number of specimens of *Distichlis*, the similarity between these two plants has been found to be so striking that it seems most natural to consider *Uniola Palmeri* as a true *Distichlis*. Professor F. Lamson-Scribner has also informed me that on seeing the plant, he immediately took it for a *Distichlis* and was unable to distinguish it from this genus.

In studying the leaf-structure of *Distichlis maritima*, several male and female individuals have been examined from different parts of North America, and although the structure is essentially the same, a few differences have been observed. If we take the entire structure of the leaf into consideration and compare it with that of the so-called *Uniola Palmeri*, described in the preceding paper, it will be difficult to find any essential difference. We may take for comparison the leaf of a female plant of *D. maritima* from western Texas of which a transverse section is figured on plate XXIII, fig. 1.

The epidermis of both faces shows the same structure as described for the superior face of *Uniola Palmeri*, having numerous warts and rather pointed epidermal expansions. The structure of the mesostome-bundles is exactly the same and the development of these as well as their distribution accords perfectly with what we have seen in *U. Palmeri*, viz.: a thin-walled and green proper parenchyma-sheath, surrounding, at least in the largest bundles, a closed ring of very thick-walled parenchyma. Furthermore the leptome and hadrome are often separated by a layer of similar parenchyma, and

groups of very thick-walled leptome-parenchyma are also observable in the strongest bundles. The stereome, the mesophyll and the uncolored parenchyma agree entirely with that of *U. Palmeri*. The leaf structure of a series of specimens of *D. maritima*, male and female, but from widely separated localities is here compared:

Arizona, ♀: The stereome is rather weakly developed and the blade is relatively broader.—California, ♀: Agrees in all details with the specimen from western Texas, described above.—New Jersey, ♀: Especially characterized by the very rough inferior face of the leaf, due to numerous warts. The stereome is very strongly developed above and below the mestome-bundles.—Montana, ♂: Differs from all the above mentioned female plants in having a closed ring of merely thin-walled parenchyma inside the proper sheath, and no thick-walled parenchyma either in the leptome or between this and the hadrome. The superior epidermis shows very long thorn-shaped and curved expansions.—Arizona, ♂: The superior epidermis shows short, thorn-shaped expansions, and long hairs, especially towards the base of the blade, situated among the bulliform cells. The inferior epidermis is on the contrary nearly smooth and without any hairs. The mestome-bundles show the same structure as described above for the female specimen, and the groups of stereome are strongly marked.—Washington, ♂: Both faces of the leaf are very rough, and the stereome shows an exceedingly strong development. There is a closed ring of very thick-walled parenchyma inside the proper sheath of the largest mestome-bundles, and the leptome is nearly divided into two separate groups by similar cells.—Vancouver Island, ♂: This specimen is well characterized from the preceding in having merely a horse-shoe-shaped layer of thick-walled parenchyma on the leptome side.—Montana, ♂ (alkaline soil): This specimen, compared with that described above from the same locality, but not from the same kind of soil, shows a remarkable difference in having a layer of very thick-walled parenchyma inside the proper sheath. Groups of similar cells are scattered in the leptome and a layer separating it from the hadrome. The superior epidermis has warts, but no long thorns, and the inferior one is nearly smooth with only a few projecting warts.

D. maritima Raf., var. *stricta*, ♂ from Nebraska: This form is especially characterized anatomically by the hairy and

rough epidermis of the superior face of the blade, where numerous thorn-shaped expansions are intermixed with conical warts. The stereome is rather strongly developed, while the mestome-bundles, the mesophyll, etc., agree with what has been mentioned above for the typical form.

D. maritima Raf., var. *laxa*, ♀ from Utah: The epidermis of the leaf is nearly smooth on both faces, being destitute of hairs and thorn-shaped expansions; otherwise it agrees perfectly with the preceding variety.

D. thalassica Humb. et Kth., ♂ from Lower California: The leaf of this species shows the same structure in most details as the preceding *D. maritima*. It is, however, quite well characterized by the very rough epidermis, of which that of the superior face shows several sharp-pointed expansions, while that of the inferior face has numerous conical warts. The largest mestome-bundles have a closed ring of thick-walled parenchyma inside the proper sheath, and the leptome contains groups of similar cells, by which it is also separated from the hadrome. The stereome represents groups of considerable size above and below the largest mestome-bundles, but is entirely wanting below the smallest ones.

D. prostrata Benth., ♂ from Mexico: The leaves are rough above, hairy below and along the margins; the epidermal expansions of the superior face are thorn-shaped, while those of the inferior are merely warts or soft hairs. The mestome-parenchyma does not show such thick-walled cells as described for the preceding species, and the leptome is but imperfectly separated from the hadrome. As to the stereome, this forms merely small groups above and below the strongest mestome-bundles, and the uncolored parenchyma is only represented by small groups between the bulliform cells and the inferior epidermis. Considered altogether the anatomical structure of the leaf in the genus *Distichlis* is very uniform, and it does not seem possible to give any special characters, by which either the varieties or the supposed species *thalassica* and *prostrata* may be distinguished from the species *maritima*; because we have seen that male and female specimens of this last show variations among themselves nearly equivalent with the differences in the two varieties and subspecies.

Of the genus *Pleuropogon*, which is closely related to *Uniola* and *Distichlis*, three species are known. Two of these, *P. refractum* Gr. and *P. Californicum* (Nees), are inhabitants of

California, while the third one, *P. Sabinei* R. Brown, is a high arctic type. Specimens of this were collected at Cape York in northwestern Greenland by the Swedish paleontologist Nathorst, who has kindly furnished me with several finely preserved individuals.

The leaf structure shows in these species a rather uniform aspect, which strikingly indicates their occurrence in wet meadows, although they live under such widely different climatological conditions. Very characteristic are the large lacunes in the mesophyll, the merely two groups of bulliform-cells in the carene, and the proportionally weak development of the stereome.

Pleuropogon refractum Gr.—The epidermis cells are rectangular with nearly straight and rather thin walls and there are on both faces of the leaf numerous conical warts. The superior face shows also several thick-walled and sharp-pointed expansions, which are directed upwards and which form long lines above the stereome-bundles (plate XXIV, fig. 9). Stomates are present on both faces of the leaf and are partly surmounted by conical warts. The bulliform cells form two groups, one at each side of the midrib; they are large and their exterior walls are entirely smooth in contrast to the other cells of the epidermis (plate XXIV, fig. 8).

The mestome-bundles represent two degrees of development; the median one (plate XXIII, fig. 6) is the largest in the whole blade and forms a slightly prominent carene. It is surrounded by a thin-walled parenchyma-sheath of which a part contains chlorophyll. Inside this, the proper sheath, is also to be observed a true mestome-sheath, the cells of which are somewhat thickened. The leptome is separated from the hadrome by a single stratum of thick-walled mestome-parenchyma, and there is a small group of stereome above and below the entire bundle. As to the corresponding mestome-bundles in the lateral parts of the blade, these differ from the median one merely by having a few cells of uncolored parenchyma on both faces, so that the stereome is not here in contact with the parenchyma-sheath. A small mestome-bundle, representing the second degree, has been figured on plate XXIII, fig. 7, where is a completely uncolored parenchyma-sheath with a thin-walled mestome-sheath inside this. The leptome and hadrome are not so strongly developed as in the preceding and they are not separated from each other by

thick-walled parenchyma. The stereome shows here but small groups and is often wanting on the inferior face, below the leptome. The uncolored parenchyma consists here of one or two cells on the hadrome side.

Concerning the distribution of these two forms of mestome-bundles it may only be said, that the smallest ones are prevalent in the whole blade. As indicated above, the stereome is rather weakly developed, and forms groups corresponding to the mestome-bundles. There are, however, besides these groups some isolated ones (plate XXIV, fig. 8) opposite the bulliform cells, and also above the middle of the lacunes on the superior face, besides one at each of the two margins of the blade. The mesophyll is strongest in the middle part of the blade, where it forms one large group on each side of the midrib; in the lateral parts of the blade it is interrupted by the large lacunes, which extend from the one mestome-bundle to the next one. The uncolored parenchyma is in the mature leaf restricted to small groups, corresponding to the mestome-bundles, as described above.

Pleuropogon Californicum (Nees.)—Plate XXIII, fig. 4, a transverse section of the middle part of the blade, shows a remarkable difference from the preceding species. There is a sharp carene on the superior face, a structure undoubtedly very rare in the Gramineæ. Otherwise the section reminds one very much of that of *P. refractum*.

The epidermis of the superior face consists of rectangular, thin-walled cells with slightly undulated side-walls, especially above the nerves. Wart-shaped expansions are numerous, although wanting above the large bulliform cells, and there are also some lines of thorn-shaped expansions in this species above the nerves. The stomates, which are equally distributed on both faces of the blade, are surrounded, not surmounted as in the preceding species, by warts. The epidermis of the inferior face differs in the presence of dwarf-cells in alternation with longer, rectangular ones, all showing distinctly undulated side-walls. Epidermal expansions are on this face merely warts, which form longitudinal lines below the stereome-bundles or sometimes also between these.

As to the mestome-bundles, these are also here, representing two degrees, of which the first one may be described from the median (plate XXIII, fig. 5). The parenchyma-sheath is uncolored and thin-walled, bordered above and below by one or

two similar uncolored cells. There is a distinct mestome-sheath, the walls of which are especially thickened inwards. The leptome and hadrome are separated from each other by two strata of thick-walled parenchymatic cells. These large bundles are supported by groups of stereome above and below, which are separated from the parenchyma-sheath by a few uncolored cells, excepting in the median one, where the mesophyll forms an uninterrupted group above the entire bundle. The mestome bundles of second degree differ in size from those of first degree; besides which the mestome-sheath shows merely thin-walled cells, and the leptome is in immediate contact with the hadrome.

The stereome agrees very well with that of *P. refractum*, but the number of isolated groups is larger here, there being three groups opposite the bulliform cells, one below and about three above the lacunes. The mesophyll and the uncolored parenchyma correspond in most details with those of the preceding species.

Pleuropogon Sabinei R. Brown.—Epidermis of the superior face consists of thin-walled, rectangular cells with nearly straight side walls, and there are numerous conical warts. The stomates are restricted to this face and are surmounted by conical expansions of the surrounding epidermis cells. The inferior face of the blade is entirely smooth; the cells show strongly undulated side-walls and are nearly equal in size.

A transverse section of half of the blade shows about the same structure as in *P. Californicum* with the sharp keel on the superior face. The mestome-bundles are also nearly the same, but it must be remarked, that in this species the mestome-sheath is merely thin-walled in both forms of bundles; besides which the leptome and hadrome are but imperfectly separated in the largest ones by a few not very thick-walled parenchymatic cells.

The stereome shows in this species a still smaller development than has been observed in the two other species, and forms here merely two isolated groups in the margins of the blade. The mesophyll and the uncolored parenchyma agree in all the details with the corresponding tissues of *P. Californicum*.

Considering now these three species of *Pleuropogon* together, it is evident that they are, in spite of their great sim-

ilarity, easily distinguished from each other by the following anatomical characters, taken from the leaf-blade:

Epidermis.

Thorn-shaped expansions on the superior face	} P. refractum. P. Californicum.
Epidermis of the inferior face perfectly smooth	
Epidermis of the inferior face with dwarf cells in alternation with long, rectangular ones	P. Californicum.
Stomates present on both faces	} P. refractum. P. Californicum.
Stomates present merely on the superior face	
Stomates surmounted with warts	} P. refractum. P. Sabinei.

Mestome-bundles.

Midrib forming a sharp carene on the superior face of the blade	} P. Californicum. P. Sabinei.
Mestome-sheath thick-walled in the largest bundles	
Leptome and hadrome separated in the largest bundles	} P. refractum. P. Californicum.
A few not very thick-walled cells between the leptome and hadrome of the largest bundles	

Mesophyll.

Forms two separate groups, one on each side of the midrib	P. refractum.
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Stereome.

One isolated group opposite each of the two groups of bulliform cells	P. refractum.
Three isolated groups opposite each of the two groups of bulliform cells	P. Californicum.
One isolated group above each lacune	P. refractum.
One isolated group below and three above each lacune	P. Californicum.

Lacunæ.

Bordering on the parenchyma-sheath of the mestome-bundles	P. refractum.
Separated from the parenchyma-sheath by a small layer of mesophyll	} P. Californicum. P. Sabinei.

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EXPLANATION OF PLATES XXIII AND XXIV.

Figs. 1-3, *Distichlis maritima*, ♀.—Fig. 1. Transverse section of half of the leaf. The black part of the figure represents the mesophyll, $\times 75$.—Fig. 2. Transverse section through the midrib, $\times 560$.—Fig. 3. Transverse section through a small mestome-bundle, $\times 560$.

Figs. 4-5. *Pleuropogon Californicum*.—Fig. 4. Transverse section of the middle part of the blade, $\times 75$.—Fig. 5. Transverse section through the midrib, $\times 560$.

Figs. 6-9. *Pleuropogon refractum*.—Fig. 6. Transverse section through midrib, $\times 560$.—Fig. 7. Transverse section through small mestome-bundle, $\times 560$.—Fig. 8. Transverse section of the middle part of the blade, $\times 75$.—Fig. 9. Epidermis of the superior face, $\times 240$.

Figs. 10-12. *Pleuropogon Sabinei*.—Fig. 10. Transverse section of half of blade, $\times 75$.—Fig. 11. Transverse section through midrib, $\times 560$.—Fig. 12. Transverse section through a small bundle, $\times 560$.